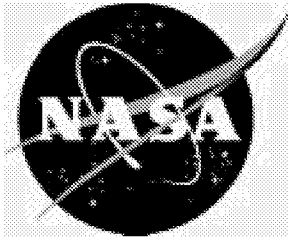# Analysis of Small Aircraft as a Transportation System

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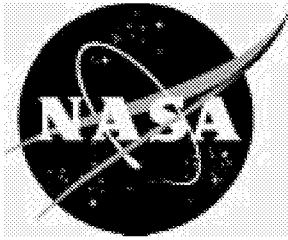- CONTRACTOR REPORT. Scientific and technical findings by NASA-sponsored contractors and grantees.

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Analysis of Small Aircraft as a Transportation System

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Abstract

An analysis was conducted to examine the market viability of small aircraft as a transportation mode in competition with automobile and scheduled commercial air travel by estimating the pool of users that would potentially switch to on-demand air travel due to cost/time savings. The basis for the analysis model was the Integrated Air Transportation System Evaluation Tool (IATSET) which was developed under contract to NASA by the Logistics Management Institute. IATSET is a macroeconomic model that predicts at a National level the mode choice among automobile, scheduled air, and on-demand air travel based on the value of a travelers time and monetary cost of the trip. A number of modifications are detailed to the original IATSET to better model the changing small aircraft environment. The potential trip market was modeled for the Eclipse 500 operated as a corporate jet and as an air taxi for the business travel market. The Cirrus 20R and an $80K single engine piston aircraft (based on automobile manufacturing technology) are evaluated in the pleasure and personal business travel market.

Introduction

The capacity of the nation's transportation system has not kept pace with the growth in demand. Thus, the costs in terms of lost time and extra fuel consumed, whether it be automobile or scheduled air traffic continue to grow rapidly for society and businesses (Ref. 1 and 2). The nation is examining solutions to this problem that range from high-speed rail to placing economic constraints on the existing system to bring demand in line with capacity. NASA is also working a broad range of potential solutions from improving the throughput of the existing infrastructure by the Aviation System Capacity Program to the introduction of vehicle systems that use smaller underutilized airports or operate independently of runways. The new vehicle approach is especially attractive in that it expands the transportation choice for the traveling public. Fortunately, NASA's investments that were made through the Advanced General Aviation Transport Experiments (AGATE) Alliance and the General Aviation Propulsion (GAP) Program are beginning to pay off with industry producing a new generation of safer and affordable small aircraft. These new aircraft greatly increase the practicality of small aircraft as a transportation mode that can avoid the congestion associated with other modes. An extensive infrastructure of public use airports is available for use by small aircraft and over 98 percent of the U.S. population lives within a 30-minute drive of one of these airports. NASA has taken the next step to assure that these airports and the airspace system can be reliably and safely used by the new generation of small aircraft without generating their own set of problems and congestion. The newly funded program is referred to as the Small Aircraft Transportation System (SATS), and details of the program are available at reference 3. Another view of the future of the air travel market, that is not all that incompatible with SATS, was expressed by the Chairman of Boeing in reference 4 in which he predicted a fragmentation of the air travel market into tiers in which small jets (10-12 passengers) would capture the top 10 percent of the market. These jets would operate as an on-demand airline catering to the least price sensitive segment of the market. The SATS vision is that on-demand air service will be economically competitive with other travel options, including automobiles, and thus available to a greater segment of the population.

This report presents the results of an analysis undertaken to examine the market viability by estimating the pool of potential users of small aircraft in competition with other travel modes. The basis for the

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analysis model used is the Integrated Air Transportation System Evaluation Tool (IATSET), which was developed under contract to NASA and is reported in reference 5. The IATSET "Bottoms-Up Model" is a macro economic model and predicts at a National level the mode choice between automobile, scheduled air, and on-demand air travel based on the value of a traveler's time and the monetary cost of the trip. Factors such as comfort, noise level, perceived safety, and dispatch reliability are modeled by modifying the economic factors and travel mode evaluation options which consist of trip fixed and variable cost and time components. Data from the 1995 American Travel Survey (Ref. 6) and the 2000 U.S. Census are used to predict the number of person trips as a function of distance and income level for each of the three modes with the lowest total cost mode being the mode of choice. IATSET is a flexible tool capable of modeling a wide range of travel scenarios. A number of modifications were implemented to the code, as reported in reference 5, to better model the changing small aircraft environment as a mode choice. These modifications are detailed in the first section of the report.

The potential trip markets are modeled for the Eclipse 500 operated as a corporate jet and as an air taxi for the business travel market. The Cirrus 20R was modeled for the single engine piston (SEP) pleasure and personal business travel market. Also, a cursory look was taken at the potential market for a SEP manufactured with automobile manufacturing techniques with a projected sales price equal to a high-end luxury car.

A recently published paper entitled, "NASA Small Aircraft Costs v. Airlines, Autos and the Economic Value of Time" (Ref.7) by Dr. Robert N. McGrath, Embry-Riddle Aeronautical University, examines the market viability of SATS. Dr. McGrath's approach is entirely different, but results in similar trends and observations as the present paper. His approach is to use software, Travel$ense, available from the National Business Aviation Association that calculates the actual trip expenses, hours, and productivity comparing traveling via business aircraft versus airline alternatives. Fifty-three city pairs were examined, airline prices were the lowest available with 30-day advanced ticket purchase, and traveler's annual salaries were assumed, so that detailed time and cost numbers were generated for the 53 city pairs. Note that the author intentionally took a conservative or in his words "non biased" approach to price comparisons, thus the 30-day advanced ticket price for scheduled air rather than unrestricted fares. The paper gives an excellent overview of how SATS competes based on price structure and schedule when both cost and time are considered, but gives no insight into the overall number of trips (i.e., size of the market). This study with its macro view focuses on the potential size of the market from a U.S. domestic point of view and treats each mode's price structure as a single set of variables that represent the averages for that mode. The original intent of IATSET was to feed a series of other models by generating small aircraft air traffic, including origins and destinations. Since airline fares, depending upon competition or lack of competition among airlines, tend to be highly variable at shorter distances, there is a good possibility that the current study underestimates the potential pool of trips for on-demand air and automobiles relative to commercial air at any particular moment when compared to the number of fares above the average. However, airline fares must be competitive with other modes of transportation over time, so mode choice based on national average fares represents a more conservative stable view of the potential market.

Model and Model Expansion

The Integrated Air Transportation System Tool (IATSET) (Ref. 5) models demand for automobile, commercial scheduled airline, personal on-demand air travel, and business on-demand air travel based on cost, time, income level, ease of access/egress, and purpose of the trip. Mode variables capture out-of-pocket expenses to make a trip and also the value of time expended, modified by the quality of the travel experience in terms of comfort, noise level, perceived safety, reliability, and flexibility. The IATSET user

has complete flexibility to modify any of the mode variables as well as to define a new mode of transportation. Total per person trip costs are calculated for each mode as a function of trip distance, block speed, access/egress times, and household income, and the mode with the lowest total cost was considered to be the preferred mode. Per capita trip data, which is also a function of household income and range, from the 1995 American Travel Survey determines the number of trips by each mode per person. There are various measures of household income and reference 5 presents a detailed discussion of those definitions and the adjustments required to harmonize the 1995 American Travel Survey household income with data bases that contain economic and demographic projections for every county and metropolitan statistical area in the United States. Hourly income was established by scaling from year 1995 dollars to year 2000 dollars, then dividing the household income by the number of wage earners per household (U.S. Census Bureau data contains number of earners per household as a function of household income), and then by 2000 hours per work year. These hourly rates were the values of time used in the total trip cost calculation. Per capita trips are multiplied by the population of that household income bracket to arrive at the number of person trips at a particular distance for that income bracket.

Several modifications were made to the IATSET model that was delivered to NASA. The top annual household income for the 1995 American Travel survey was $150K and above which resulted in the top hourly rate being $66.81 per hour. The 2000 Census data show 2.699 million individual earners above the age of 15 who make considerably more than $66.81 per hour. The top bracket for the Census data is $250K and above with a mean income of $492K or $247 per hour for that bracket. The data also shows 4.978M households with annual income above $150K. Since per capita trips and the ability to afford on-demand travel increases rapidly with income, a better definition of higher income households and individual income earners was needed to properly capture the market potential for on-demand air travel. Further, the income or hourly wage numbers were structured differently for personal travel and business travel. Year 2000 Census data for household income was used to determine the value of time for pleasure and personal business travel, and the Census data for individual income earners was used as the value of time for business travel. Additional income levels of $150K-$199K, $200K-$249K, and $250Kand above were established with the population size and mean income numbers from the U. S. Census Bureau 2000 Annual Demographic Survey. Since the American Travel Survey top income level was $150K and above, the per capita trip numbers from the survey were plotted and then extrapolated to the higher income levels. Any error introduced by such extrapolation is probably well within the accuracy of the original survey, and without the improved higher income definitions the model correlated poorly with existing on-demand data.

Two more minor modifications were made to IATSET as delivered. The mode variables for on-demand air did not include the range of the vehicle as an input. Since refueling civil aircraft requires a time consuming stop, the formulas for the trip cost were modified to accept aircraft range and to add an hour for each flight segment when the range is exceeded. The second modification was one of convenience. The original IATSET added the per capita personal and business trips together before determining the number of trips by multiplying by the associated population. The personal on-demand market, which largely comprises piston aircraft, and the business market, which includes jet and turboprop aircraft, are really two separate models. An additional step was added to calculate the potential trips associated with personal and business travel separately before adding them together. This allows more insight into the absolute numbers as well as more insight into how on-demand business or personal travel captures trips from the automobile or scheduled airlines.

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Baseline Values

The unmodified IATSET baseline values were calibrated on the actual 1995 data for personal use vehicles (cars, trucks, vans, motor homes, and motorcycles) and airplane trips and compared very well. However, corporate and personal airplane trips in the unmodified model were about half the number of itinerate general aviation (GA) airplane trips reported in the FAA Terminal Area Forecast (TAF) data. The under- representation appears to be largely in business travel, and the lack of higher income bracket details was probably the largest contributing factor. However, the data sources vary widely in the number of person trips in 1995 for GA aircraft. The 1995 American Travel Survey indicates 5.29M person trips over 100 miles (one-way distance) by noncommercial aircraft, while the FAA TAF data indicates 5.22M itinerate airplane GA round trips from airports with air traffic control service. Note that FAA data is aircraft operations and has no distance associated with it, so some portion of these trips could be less than 100 miles between origin and destination. However, these are airplane trips and the number of passengers (including the pilot) per trip would average more than one, and the operations from noncontrolled airports are not included, so it's reasonable to assume the number of person trips is considerably higher than indicated in the American Travel Survey.

As the model was being modified to reflect the higher income brackets, the number of automobile and scheduled airline trips was monitored to be consistent with the original model. However, the number of scheduled commercial air trips increases approximately 5 percent due to the higher incomes modeled, but the original model under predicted scheduled commercial air by a little more than this (Ref. 5) so correlation with data actually improved. (Bas-lining GA with a macroeconomic model as a transportation mode choice based on time and cost considerations is difficult because much of the GA activity is due to love of flying and flying as a hobby.)

The purpose of the mode choice activity is to determine the characteristics and distribution of small aircraft as a competitive travel mode, so an attempt was made to baseline on-demand air travel along this vein. The potential market is defined by the number of person trips for which on-demand air travel has the lowest cost in terms of travel cost and travel time. In general, for an airplane class such as business jets, the magnitude of the potential market is defined by the airplanes with the lowest fixed and variable costs. More expensive aircraft with slightly better mission performance are a subset of the broader market appealing to a smaller set of higher income level travelers. Three airplanes were used to baseline the market: Citation II business jet, MU-2 Marques turboprop, and a single engine piston represented by the Conklin and de Decker SEP generic. The Conklin and de Decker Aircraft Cost Evaluator (ACE)(Ref. 8) was used to develop relative operating costs for the aircraft. Conklin and de Decker is a consultant and information provider for business and GA, and ACE contains data for over 350 small aircraft. The year 2000 on-demand air travel market was projected by the modified IATSAT to be 9.74M person trips. That number is considerably more than the number attributed to noncommercial aircraft extrapolated from the American Travel Survey and more in line with the FAA observed 2000 general aviation itinerate operations. The 9.74M on-demand person trips will serve as the base market from which new small aircraft and operations will be evaluated. Any potential on-demand market will be quantified as in addition to or as growth to this base market and are trips diverted from either automobile or scheduled commercial airline travel. All numbers are for the year 2000 population and income statistics but can be projected to future years using Census projections. Since new, more efficient aircraft also replace older aircraft, the actual sales for new aircraft will be greater than the growth market. The numbers are cast in terms of expansion over the existing system.

Business Travel

The business travel segment of the market is the most sensitive to the efficient use of time and tends to pay premium fares to keep travel options unrestricted. Business jets are already the most rapidly growing segment of the GA market with over 500 being added each year. Fractional ownership has been a boom to consolidating the needs of multiple users whose individual or corporate travel demands are less than required to economically utilize their own jet. But in general, IATSET results indicate that on a cost/time basis, the currently available business jets will appeal only to the very highest income levels. Keep in mind that IATSET is a macroeconomic model and specific scenarios in terms of actual city pairs or trip details can be constructed to broaden the appeal of current business jets. Both approaches are valid, but IATSET provides a national perspective on the on the potential market size as to the number of trips likely to favor one travel mode over another.

As discussed in the Introduction, earlier NASA sponsored research is beginning to pay off in terms of a new generation of safer and more affordable small aircraft which use small, efficient turbofan engines based on GAP technology. The Eclipse 500 (Ref. 9) is projected to be commercially available in January 2004, and both the initial purchase price and operating costs are projected to be considerably less than currently available business jets. The Safire S-26 is a second business jet with price breakthroughs and will follow with delivery in June 2004. The potential market is defined in terms of the number of business trips with the lowest total cost as a function of money cost and time. A note of caution is required before interpreting the results, and that is the capture of any significant portion of this market is dependent on matching service levels with user needs. The lowest cost mode, which is sole ownership, results in the greatest number of potential trips but doesn't lend itself to very deep penetration of the market because few in the pool of potential users need the number of trips to economically utilize the aircraft. Fractional ownership partially solves this problem, but the individual or corporate owner still requires a significant number of trips for the economics to work. Air taxi or charter provides the greatest flexibility, but also tends to be the most expensive but should be able to capture most of its potential pool of trips.

The number of potential person trips (round trips) associated with the trip costs and block speed of the Eclipse 500 carrying 4 passengers and operated as a typical corporate jet that is wholly or fractionally owned are shown in Figure 1(a). The trips are additional trips over the 2000 market that are generated due to the lower aircraft price and direct operating costs. The potential number of additional business trips for which a small jet is the mode choice compared to business class airfares and automobile travel is very large and exceeds today's trip market of approximately 4M person trips even for the most expensive current per trip option which is fractional ownership. A striking number of potential additional person trips results from reducing the traditional pilot and copilot corporate crew to a single pilot which results in total trip cost being much more competitive with business class fares on scheduled airlines. As shown in figure 1(b), a large number of aircraft would be required to generate this number of trips. The number of aircraft assume 250 flights per year for corporate ownership and 400 flights per year for fractional ownership which are typical for these type operations. Again, a relatively small share of this market can be captured because few users either individually or organizationally have the need to justify owning a business jet. Fractional ownership penetrates more of this market, but is still targeted toward those who need 25 to 200 flights per year.

Maximum service to the potential on-demand air travel market is provided by allowing the traveler to buy-by-the-flight, as in air taxi and charters. Per trip costs may be higher than those for ownership options, and that results in fewer trips for air taxi as the preferred mode choice, but virtually the entire number of trips can be captured since the trips are purchased one at a time. Eclipse Aviation envisions that "for those who don't want to pilot themselves, ... that aircraft charter, complete with professional

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pilot, will typically be competitive with a full-fare airline ticket." Prospective air taxi operations utilizing the Eclipse have indicated rates could start about $600 per hour (Ref.10). Without knowing the details of intended coverage, policy on placement flights, and projected aircraft utilization in flights per year, it is difficult to discern if this rate is sufficient to provide a viable business model or is a marketing rate to draw attention to the business, but it compares favorably with the corporate hourly rate which is estimated to be a little less than $500/hr but is also based on much less utilization and doesn't include a profit. Thus looking at the market starting at $600 per hour and above is reasonable.

The number of potential person trips resulting from various Eclipse 500 air taxi pricing options is shown in Figure 2(a). The single pilot number from Figure 1 is shown for reference and all numbers are for a single pilot and 4 passengers. If the $600 per hour is approximated by $1.72/ mile (statute) an extremely large number of person trips results as the mode of choice. However, over half are in the 150 to 250 mile (one-way) range and most certainly could not be served profitably at a single flat rate of $1.72/mile with no minimum charge. As with automobile taxis, some minimum would be required, so rates of $200, $400, and $600 plus $1.72/mile were examined and the results are shown. A rate structure similar to this would allow the air taxi service provider to capture the fixed cost on each flight. The data in the figure indicates how the overall national market responds to these fare structures and no judgment is made on the part of the author as to the required yield or fare to establish a successful air taxi service. The required yield will depend on a company's cost structure and coverage of the market. Most likely the fare will vary with the origin and destination due to the need to reposition the aircraft. Fares should drop over time as the system matures and aircraft repositioning becomes less of a factor. As Figure 2(b) shows, the year 2000 potential markets for the $200, $400, and $600 plus $1.72/mile rate structure are all sizeable relative to today's fleet and would require approximately 7,800, 2,900 and 1,300 airplanes, respectively. Future markets would grow as least as fast as the population and income level, but are more likely to grow much faster due to increasing congestion in automobile and scheduled air traffic. The large differences in the number of aircraft for corporate rate structure and air taxi is the result of average corporate utilization of 250 yearly flights while the air taxi is assumed to have 1200 fare flights per year. Another way to look at the size of the market is the total revenue generated. For instance, if the average flight is 500 miles, the markets are approximately $10B, $4.5B, and $2.2B, respectively. Another candidate rate structure would be to charge for air taxi service in hourly increments. The numbers were generated for a rate structure of $800 for the first hour and then in increments of $600 per hour thereafter with a full hour being charged for any fraction and are shown on the far right in Figures 2(a) and (b). This is also a potential healthy market and would require over 5500 aircraft to meet all of the year 2000 demand. All of the numbers are for the on-demand market generated in addition to the existing markets for air taxi, chartered, corporate, and fractional ownership operations, i.e., this number of person trips are diverted from either automobile or scheduled air due to on-demand air becoming a more attractive mode of choice. A successful air taxi operation would also be expected to capture some of the existing market, thus increasing the number of air taxi trips and required aircraft over those presented.

Figure 3 indicates the sensitivity of the market to the assumption that there is an average of 4 passengers per flight. About 75 percent of the potential number of person trips are lost in terms of mode choice if the average number of passengers drops to 3. Although this is a large decrease in the number of person trips, approximately 2800 airplanes are still needed to service the market at 3 passengers per flight. At 2 passengers or less per flight, the service is not a competitive mode choice in terms of cost/time. Again, these numbers are the result of a national level macroeconomic model, and additional detailed comparison with actual airline fares and schedules between actual city pairs and with travel plans that include visiting multiple sites in a day would present opportunities for air taxi at lower passenger loads similar to those existing in the current market.

In summary, the advent of low priced business jets such as the Eclipse 500 and Safire S-26 has the potential to generate a healthy, competitive air taxi market that could become the mode choice over the automobile at short ranges and commercial scheduled air at longer ranges. The realization of this market will depend on developing a supporting infrastructure that does not increase delays with growth in general aviation aircraft and provides the reliability and safety associated with other transportation modes. Based on today's demand, an air taxi system has the potential to increase the number of flights per day somewhere between 10,000 and 24,000. While these flights will spread out among the of smaller general aviation airports, they will add greatly to the en route congestion as the business jets vie for the airspace occupied by commercial jets.

Pleasure and Personal Business Trips

Although any aircraft can be modeled into either the pleasure and personal business or business categories, the pleasure and personal market tends to be dominated by self-piloted SEP aircraft. The personal travel market is also more difficult to model in a macroeconomic sense in that it spans trips such as a single person on a one-day trip to the whole family on a week long vacation. The fixed trip costs, which include expenses such as parking, taxi, and/or rental car, will vary considerably between these type trips and have a great impact on the mode chosen. The default values in IATSET are set to reflect family vacation scenarios and thus penalize scheduled and on-demand air travel with large fixed trip cost relative to automobile travel. Due to the great variability in trip fixed cost, most of the data in the report were generated with just the cost of traveling to and from the destination considered, that is, no fixed trip cost, however, a sensitivity to trip fixed cost is presented.

The potential numbers of person trips as the mode of choice generated by an aircraft with the economics and performance of the Cirrus 20R are shown in Figure 4. Mode choice is dictated by the value of time and cost advantage with the passion for flying or flying as a hobby factored out since the study is for transportation across the complete populace. Average operation for SEP aircraft is about 100 flights per year. At 100 itinerant flights per year, the Cirrus 20R would not capture any additional trips that are currently being taken by automobiles and commercial aviation and would thus not be expected to increase GA as a transportation mode. If aircraft utilization could be increased to 400 flights per year without an increase in overhead expenses, a substantial pool of 24.5M personal trips is developed. At 600 flights per year the pool grows to almost 48M person trips. However, since the trips are self-piloted, at least one person on each flight must be a pilot so penetration of this market may be small. The numbers also indicate that the Cirrus 20R as a professional piloted air taxi would not capture any personal trips from auto and commercial air markets. The number of aircraft needed to meet the market is not shown as it can vary widely based on the assumptions about the number of future pilots in the U.S. population. What can be gained from the figure is that there is a substantial potential market, and that how much of that market that can be captured will depend on reducing the cost per trip of available SEP aircraft. This can be done by much greater utilization and reducing the difficulty of flying to approach that of driving an automobile to overcome the fact that only about 1/4 of 1 percent of the U.S. population is licensed to fly some type of aircraft.

Figure 5 illustrates the effect of trip fixed cost. Trip fixed costs are assumed to only be the cost of a rental car at the destination for five days at $40 per day. Again, at the current rate of 100 flights per year, there are no new trips captured from auto and commercial air. The pool of potential trips at a flight rate of 400 flights per year drops from 24.5M to 1.7M when the trip fixed costs are partially considered. Since there can be other fixed cost such as airport parking or a taxi to-and-from the originating airport, even at 400 flights per year, an airplane with the economics and performance of the latest SEP designs available

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will not generate significant new GA travel for trips of extended stay. This figure also explains why a segment of the personal aircraft market continues to strive to develop an affordable roadable aircraft.

A cursory look was taken at an airplane with a purchase price of $80K and with the performance of the Cirrus 20R. Some elements of the GA industry project that the application of automobile manufacturing techniques to SEP aircraft could result in aircraft priced approximately the same as high-end luxury automobiles, thus the $80K price. Assuming that speed, range, and seating is comparable to the Cirrus 20R, the year 2000 pool of person trips is 6M and 48M for the aircraft with flight rates per year of 100 and 400, respectively (Figure 6). (No fixed trip costs are included.) The costs for the $80K airplane continue to assume annual fixed costs such as the airplane is housed in a rental hangar, weather service subscription is included, and there are recurrent pilot training costs. Assuming the aircraft utilization and the ease of flight/pilot challenges can be solved, the new market could reasonably increase today's SEP fleet by more than 25 percent as a travel mode of preference based on cost and time saved.

Because of the low block speed, the SEP has a relatively narrow window of advantage between automobile travel and commercial air and any reduction in block speed narrows that window even further. Generally lower SEP aircraft price means lower performance. If that is true for the $80K SEP, then the pool of potential trips would be substantially reduced. The data in Figure 7 indicates that over 40 percent of the number of person trips are lost if the trip block speed drops from 162 mph to 140 mph. The higher cruise speed of commercial jets starts to overcome the access/egress time advantage of the SEP aircraft at about 450 to 500 miles.

The macroeconomic look at SEP aircraft as a mode choice for pleasure and personal business travel indicates great potential for those aircraft to become a competitive mode of transportation when compared to automobile and commercial scheduled air travel for shorter range trips, but with a much less clear path to achieve that than business jet aircraft. To achieve that potential the fixed and direct operating costs of SEP need a cost parallel in their class similar to the Eclipse in business jets. Dramatic cost reductions could be achieved by either of two events and together the events have great synergism. SEP aircraft have historic utilization rates that are very low when compared to commercial modes of transportation (much less than 5 percent of a typical commercial airliner). So as technologies that support safe and reliable small aircraft travel become available, the market needs to respond with approaches to increase the SEP class of aircraft utilization to achieve cost effectiveness. Potential solutions could be a network of co-ops or nation-wide airplane rental companies more like the auto rental companies. With increased potential demand, the possibility that SEP aircraft could be mass-produced with automobile manufacturing processes is increased. Overhanging this scenario is that the pleasure and personal business travel cost structure is based on a member of the travel party piloting the aircraft, and incentives must also be there for many more people to become pilots because they perceive GA as an attractive, cost-effective mode of transportation. The macro-economic model indicates that an air taxi based on SEP aircraft would not divert additional travelers from automobile or scheduled air.

Concluding Remarks

A macroeconomic model the Integrated Air Transportation System Evaluation Tool (IATSET), that was developed under contract to NASA to model small aircraft traffic was modified to strengthen the market demand aspect of the tool. Modifications included a definition of the individual income classes for the business travel model and a better definition of higher household incomes for the pleasure and personal business travel model. IATSET was used to develop a top-level perspective on the potential market for several new and emerging aircraft for personal and business travel. Utilizing technologies developed in previous NASA programs, new, low-cost business jets are being marketed. The pool of

person trips for which a low-cost, professionally-piloted, business jet would be the mode choice based on cost and time saved is large. The problem that very few individuals or organizations require the full use of a business jet is solved under the concept of affordable jet air taxi. From an economic point of view, the potential pool is smaller than for a fully utilized owned aircraft due to increased cost of air taxi, but the economically serviceable portion of the pool may be the complete pool. The additional demand for business jet service could increase the fleet 50 to 100 percent based on year 2000 demand numbers. The demand would be expected to grow in the future with both population and income as well as in response to increasing congestion in highway and scheduled air travel.

Pleasure and personal business travel by single engine piston (SEP) aircraft that are piloted by a member of the travel party have more obstacles to overcome as a preferred travel mode. The costs of owning and operating these aircraft need reductions similar to those occurring in the business jet market. SEP aircraft have historically averaged only about 100 flights per year (50 trips), which results in high fixed cost per flight. For the costs per flight to be more aligned with those needed to capture trips from highway and scheduled air travel, the utilization of SEP aircraft needs to be much higher, or the price of the aircraft needs to be much lower. Fractional ownership of SEP's, a network of co-op's, or a network for rentals similar to automobile rentals could be market solutions to meet the demand. The application of automobile manufacturing techniques to SEP aircraft are being investigated, and airplane price reductions on the order of 50 percent are being projected. The combination of lower priced aircraft and high utilization results in a very large pool of potential trips for which this is the mode of choice. The biggest barrier to capturing this pool is the assumption that a member of the travel party is piloting the airplane. The cost, time, and difficulty of becoming a pilot would need significant reduction to establish this market. The macroeconomic model indicated negligible additional demand due to the higher costs for professional piloted SEP aircraft in the personal travel market.

The macroeconomic model is intended to capture national level demand for a particular mode of transportation based on the cost, time, income level, ease of access/egress, and purpose of the trip. Although significant potential market for on-demand aircraft is projected, the projections are most certainly conservative in terms of potential trips that could be diverted from scheduled airlines. Ticket prices in the short to medium range market are highly variable, and a recent sampling indicates an under prediction of scheduled airline fares at these distances for the IATSET default values which represent all distances with a single equation. Further modification of IATSET will be undertaken to better capture the range of airline fares as a function of trip distance rather than attempt to represent the entire system with a single set of fare price variables. Even more detailed market studies could be conducted by examining the actual city pairs and fares in the system to determine the mode choice, but because the shorter range fares for commercial air travel tend to be high because of lack of competition in many of these markets such detail may actually result in overstating the market since those fares may drop rapidly with the introduction of competition. So the plan is to vary fares with distance at the national averages so that the pool of potential trips diverted from other travel modes represents a stable, competitive market.

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Figure 1(a)- Eclipse 500 Corporate Operation

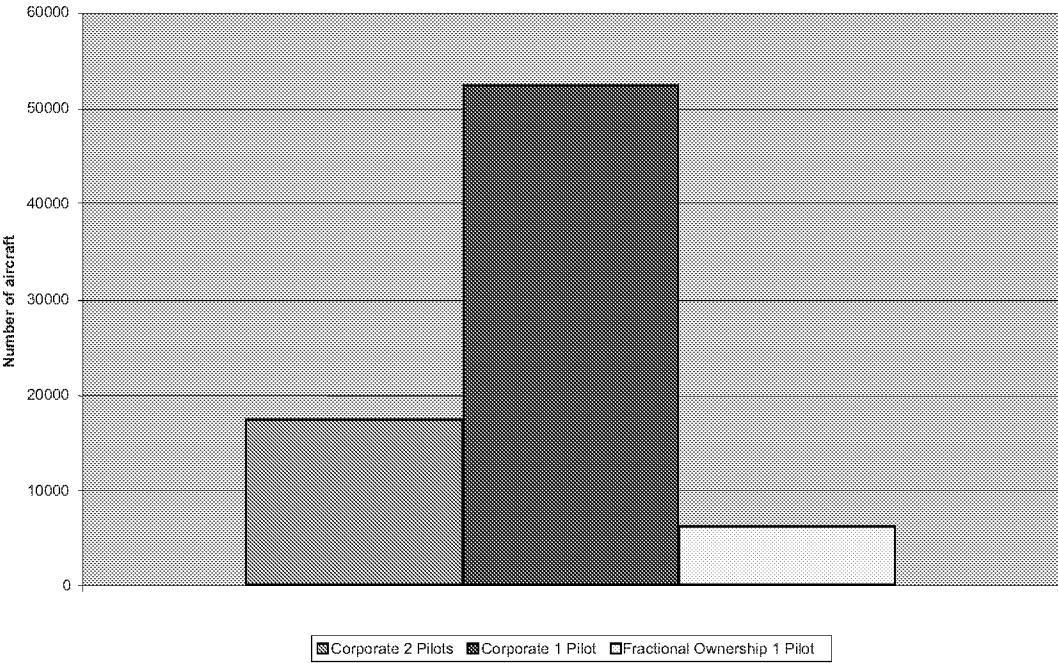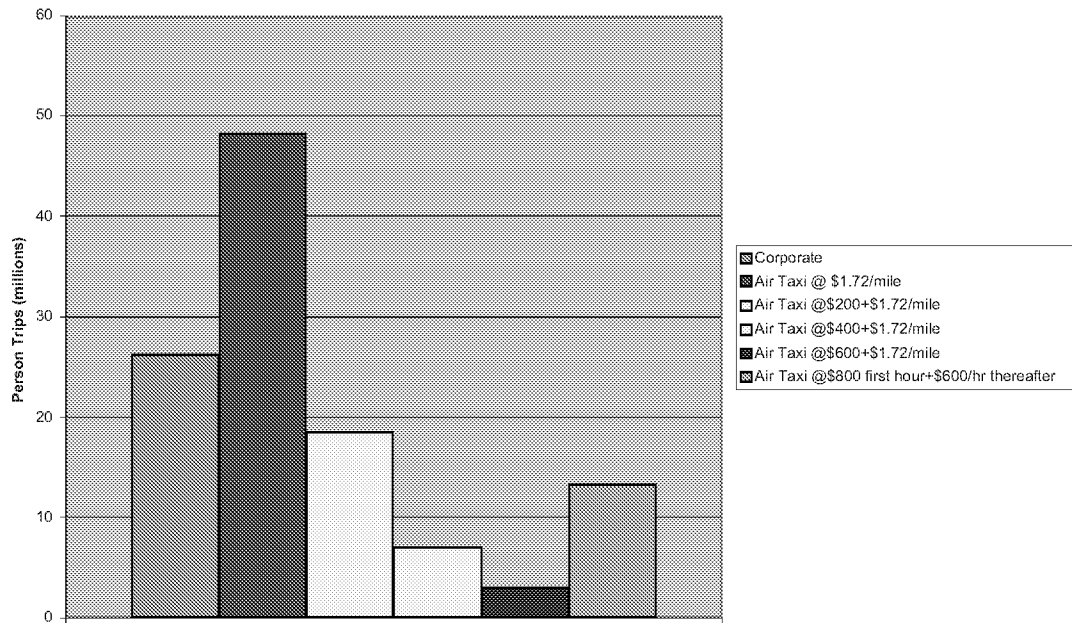Figure 1(a)- Eclipse 500 Corporate Operation

Y-axis: Person Trips (millions), 0 to 30

Legend: Corporate 2 Pilots | Corporate 1 Pilot | Fractional Ownership 1 Pilot

Figure 1(b)- Eclipse 500 corporate Operation

Figure 1(b)- Eclipse 500 corporate Operation

Y-axis: Number of aircraft, 0 to 60000

Legend: Corporate 2 Pilots | Corporate 1 Pilot | Fractional Ownership 1 Pilot

11
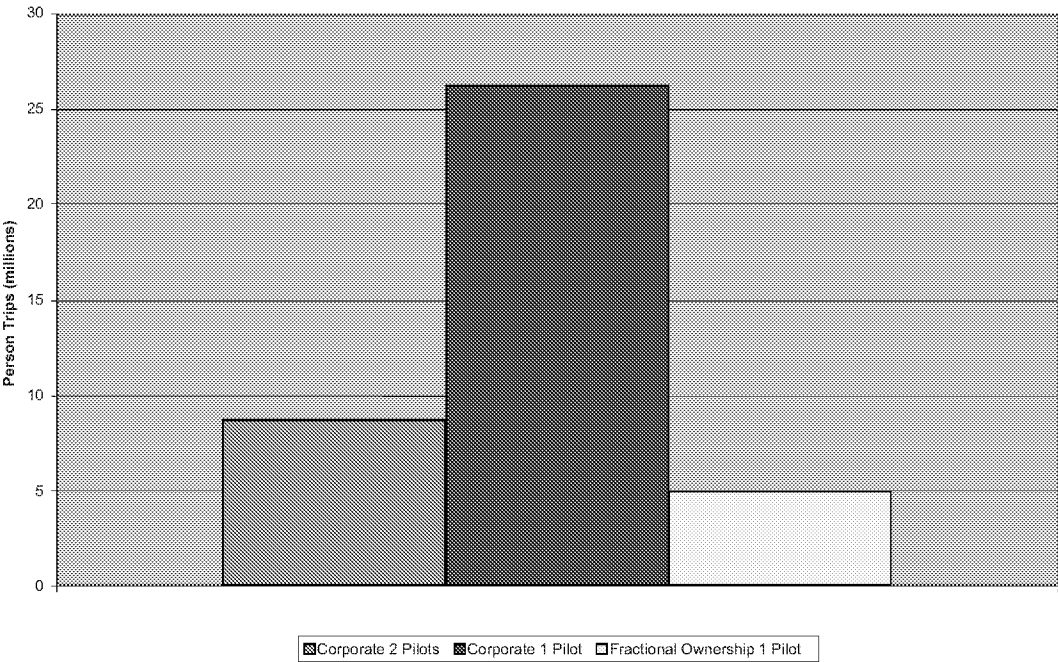
Figure 2(a)- Eclipse 500 Air Taxi

Legend:
- Corporate
- Air Taxi @ $1.72/mile
- Air Taxi @$200+$1.72/mile
- Air Taxi @$400+$1.72/mile
- Air Taxi @$600+$1.72/mile
- Air Taxi @$800 first hour+$600/hr thereafter

Figure 2(b)- Eclipse 500 Air Taxi

Legend:
- Corporate
- Air Taxi @$1.72/mile
- Air Taxi @$200+$1.72/mile
- Air Taxi @$400+$1.72/mile
- Air Taxi @$600+$1.72/mile
- Air Taxi @$800 first hour+$600/hr thereafter

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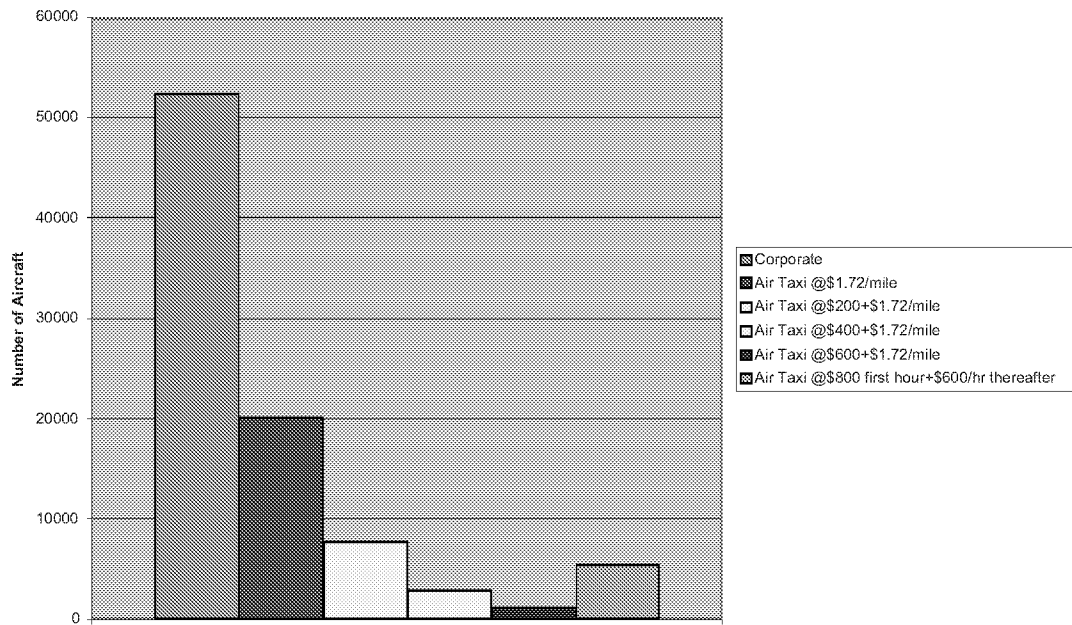
Figure 3(a)- Eclipse 500 Air Taxi@$200+$1.72/mile

Legend: 4 Passengers, 3 Passengers, 2 Passengers
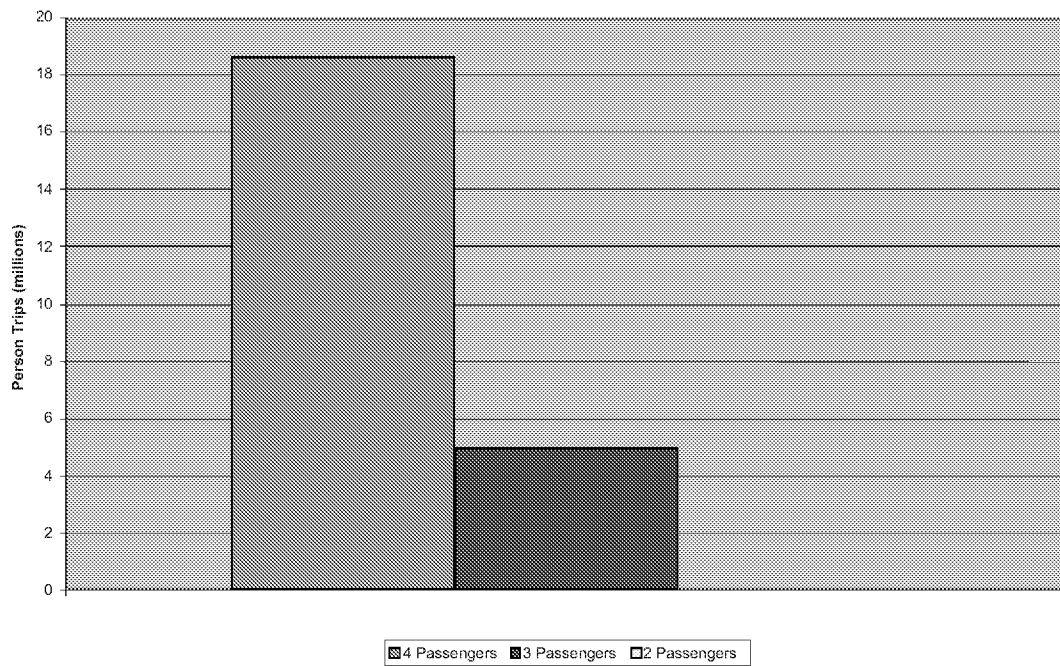
Figure 3(b)- Eclipse Air Taxi@$200+$1.72/mile

Legend: 4 Passengers, 3 Passengers, 2 Passengers

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Figure 4- Cirrus 20R

Legend: ▨ 100 Flights/year ▨ 400 Flights/year ☐ 600 Flights/year

Y-axis: Person Trips (millions)
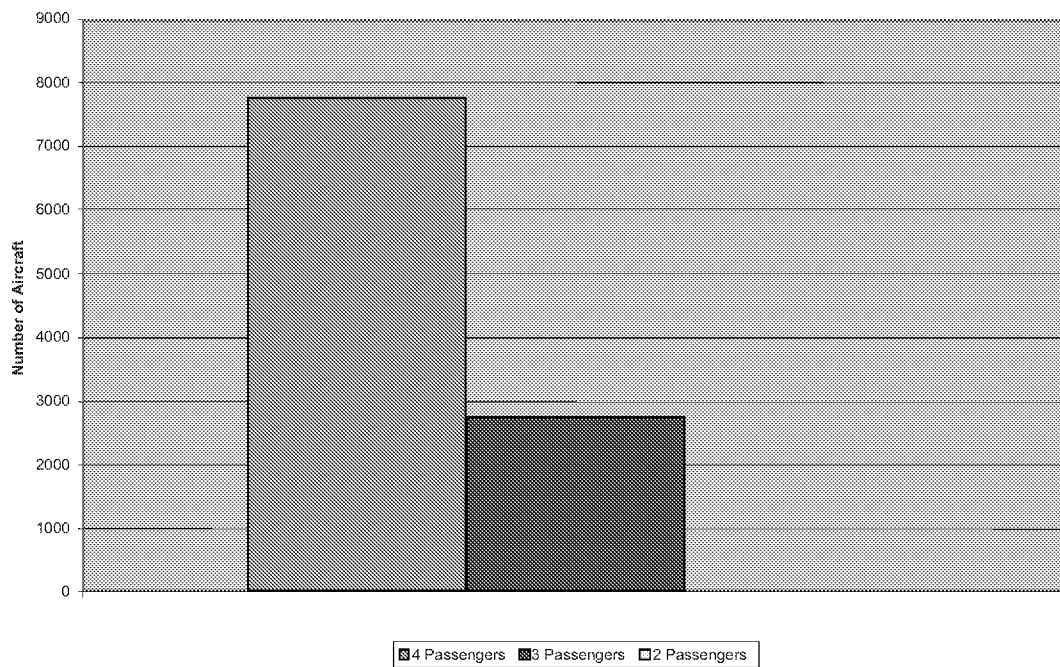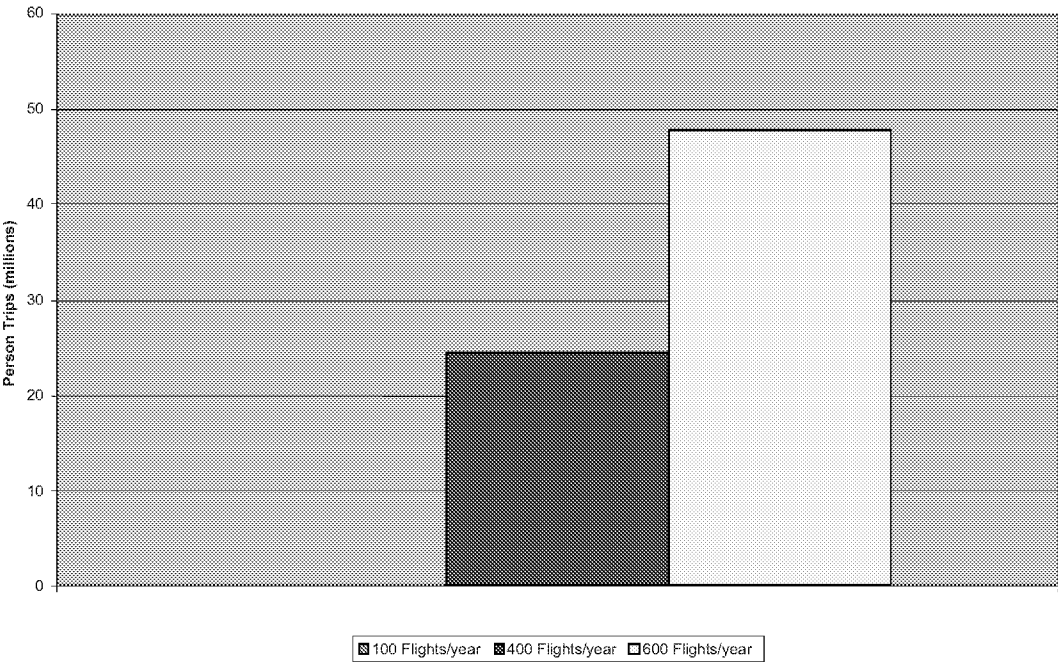
Figure 5- Cirrus 20R @400 Flights/Year

Y-axis: Person Trips (millions)

Legend:
▨ No Trip Fixed Costs

▨ Trip Fixed Costs: Scheduled Air+On-Demand Air+$200

14
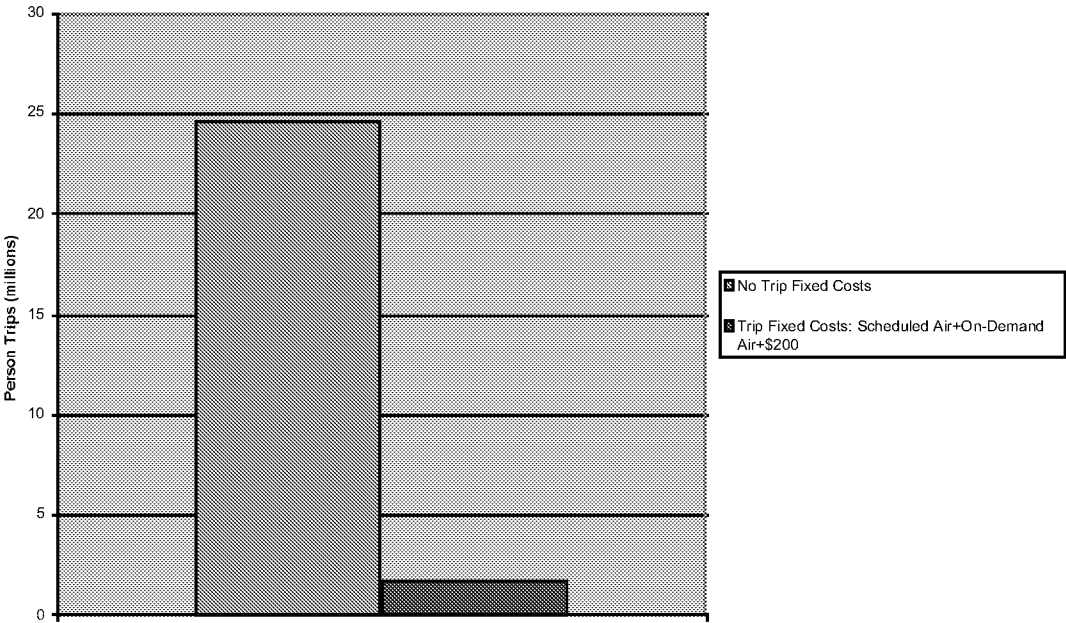
Figure 6- $80K Single Engine Piston

Person Trips (millions)

■ 100 Flights/year ■ 400 Flights/year
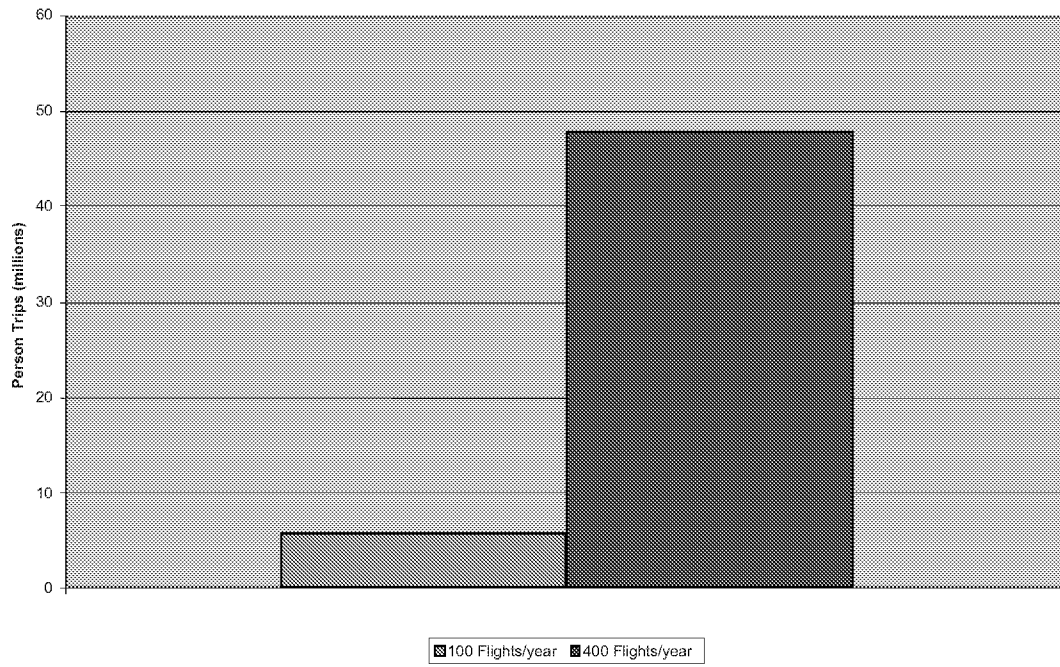
Figure 7- $80K Single Engine Piston (400 flts/yr)

Person Trips (millions)

■ 140 mph Block Speed ■ 162 mph Block Speed

15
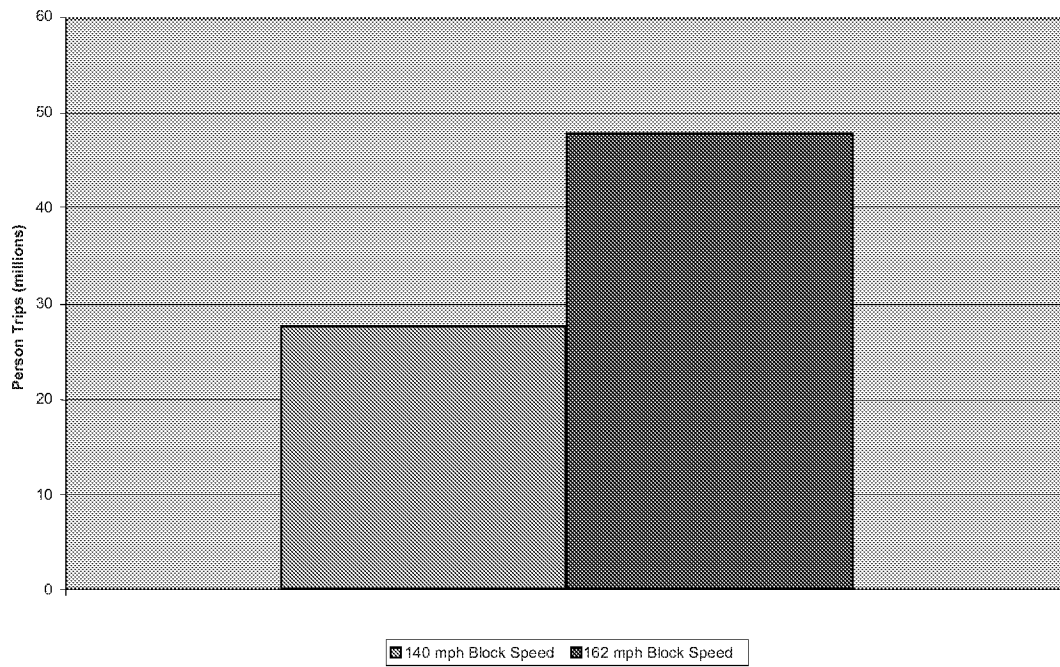
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13. ABSTRACT *(Maximum 200 words)*
An analysis was conducted to examine the market viability of small aircraft as a transportation mode in competition with automobile and scheduled commercial air travel by estimating the pool of users that would potentially switch to on-demand air travel due to cost/time savings. The basis for the analysis model was the Integrated Air Transportation System Evaluation Tool (IATSET) which was developed under contract to NASA by the Logistics Management Institute. IATSET is a macroeconomic model that predicts at a National level the mode choice between automobile, scheduled air, and on-demand air travel based on the value of a travelers time and monetary cost of the trip. A number of modifications are detailed to the original IATSET to better model the changing small aircraft environment. The potential trip market was modeled for the Eclipse 500 operated as a corporate jet and as an air taxi for the business travel market. The Cirrus 20R and a $80K single engine piston aircraft (based on automobile manufacturing technology) are evaluated in the pleasure and personal business travel market.

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